Keith Evan Green • Clemson University

Architecture Plus

The Collaborative *Animated Work Environment* Design Research Project

An architect who acknowledges no obligation to society at large, who gives no heed to the just claims of posterity, is not an architect….

- Louis H. Sullivan, *Kindergarten Chats*

A study on architectural faculty research published in the *Journal of Architectural Education* showed two disturbing tendencies: (1) that a mere 18.5% of architecture faculty offering peer-reviewed papers at conferences sponsored by the *Association of Collegiate Schools of Architecture* presented "design research projects" (i.e. research involving the activity of designing something); and (2), only 1% of all research presented by architecture faculty was "collaborative" [21]. These two statistics together reveal the unfortunate character of research practices across architecture faculty; that architecture faculty members are largely disengaged from design research and almost never collaborate with colleagues in other disciplines. In a world that is ever-more complex, socially and technologically, critical issues of the built and natural environments demand the very attention that architecture faculty neglect: design research undertaken as a collaborative pursuit. The expanding knowledge economy, new technologies associated with computing and materials science, striking demographic changes, and unprecedented sprawl are concerns far too complex for architects working alone; these concerns beckon, instead, a response from collaborative design research groups.

A Case Study of Collaborative Design Research: The AWE Project

The dramatic shift in the nature, place and organization of working life, as well as the sophistication of information technologies employed in work, have prompted the author to assemble a trans-disciplinary research team – myself as architect, a robotics engineer, a human-factors psychologist, and a sociologist – to develop a work environment for the Information Age. An introduction to the AWE Project, just initiated and recently funded by the National Science Foundation, offers a model of collaborative design research and reveals certain difficulties architecture faculty researchers must overcome to accomplish such work.

A recent trend in the nature, place and organization of working life is the growing complexity of work, the emergence of new working populations (older workers, under-skilled workers, telecommuters and flexible shift workers), and the increasing likelihood that workers are working, at least part-time, at home. As the home becomes more an office, the office is becoming more a home, where "hot desks," lounges, sofas, WI-FI and internal networks have replaced office cubicles and hard-wired, isolated workstations. These dramatic transformations in the nature of work, combined with unprecedented new technologies associated with working life, suggest a re-evaluation of the relations between workers, their technologies and their work

environments, and a redesign of the work environment itself as a socially and technologically responsive system occupying both home and office.

While investigators continue to realize promising components of the "intelligent" work environment – projectors, screens, tablets, sensors, actuators and other digital devices – our collaborative team is focused upon a novel but wholly compatible aspect of the "intelligent" work environment: the physical work space itself. The *Animated Work Environment* [AWE] concept challenges knowledge and understanding in both Architecture and Engineering by defining the "robot as a room" and the "room as a robot." This is a redefinition of what constitutes Architecture and Robotics and is not only a conceptual leap in the respective disciplines, but a fully appropriate, even necessary response to a condition in working life that is both social and technological.

The need to "program the room" both stimulates and is enabled by existing and ongoing efforts in Information Technology and "intelligent environments." More broadly, AWE challenges present understanding in both Architecture and Computer and Information Science and Engineering by recognizing computer software, networks and devices not as isolated aspects of a digital society but as constituents of an integral environmental system, far more productive and more accessible than any of its parts. In this way, the AWE concept aims to expand the vision of researchers, developers and manufacturers of information technologies to recognize the physical environment as an integral and necessary part of the dynamic interaction between people and the digital realm.

Introducing AWE

The ongoing dramatic transformation in working life, including the introduction of ever new digital technologies, presents problems and opportunities to all workers, particularly to segments of the working population that are emerging and neglected: telecommuters, flexible shift workers, single parents, elders, recent immigrants, the obese, the handicapped and, other individuals requiring special accommodations.

This dramatic shift in the nature, place and organization of working life motivates our research which, in the simplest of terms, involves the designing, prototyping, demonstrating and evaluating of a prototypical "robot-room" with embedded Information Technologies – an "Animated Work Environment" (figures 1, 2 and 3).

fig. 1: AWE concept - SLEEPING

The strength of AWE is made clearer by recognizing what it isn't: it isn't a building, or a room, or a "stand-alone" device, or a software application, or a piece of furniture. Instead, AWE is a user-friendly, programmable environment, both digital and analog, high-tech and low-tech, fitted to home and office, that users adjust along a continuum, providing the sense of being more "at home" or more "at work," more leisurely or more productive, more efficient or more innovative, while facilitating multiple activities.

In concept, AWE is envisioned as an information-rich environment featuring the ability to continuously "morph" to accommodate a wide range of user needs. At the core of this environment (though not exclusively comprising it) are smooth, continuously deformable "smart" surfaces whose configuration, and hence functionality, are user-controllable. In addition to this novel aspect, AWE embodies a range of "off-the-shelf" Information Technology (IT) components: embedded commercially-available sensors that, when suitably exploited, make AWE user-friendly and intelligent; radio-frequency identification (RFID) tags that allow AWE to associate printed and digital materials; and integrated display screens, scanners, projectors, keyboards and audio speakers that make AWE useful as a total work environment programmable to suit a range of work needs and situations.

Research Precedents

Few precedents for AWE are found in the work environments being researched and developed by IT and Architectural Design industries. The most promising of these efforts are perhaps IBM's "Blue Space" [2] and IDEO's "Q [1], both important steps towards integrating IT and Design. Compared to our vision of AWE, however, "Blue Space" contains fewer and more timid "smart" components and a narrower range of embedded IT peripherals; and "Q," accommodates only one user who must be seated, supports a far more limited range of work activities, and cannot be reconfigured in the way AWE promises. A more enticing integration of design and IT is found in numerous efforts offered by Phillips as "Ambient Intelligence" [3]; but as single products rather than complex environments, these too fall short of AWE's promise.

Additionally, while numerous research efforts in ubiquitous computing [4][5][6] [9][10][18] are viewed by the AWE team as significant, compatible, and parallel efforts to our own research, the difference between the AWE project and these efforts is made clear by a compelling research project from University of Massachusetts titled "NeTS: Animated Spaces for the Digital Society" [18]. While this project's title and broad objective to "bridge the gap between the physical and digital worlds" sounds strikingly similar to our own, "NeTS" focuses on employing Radio Frequency Identification to link objects with their placement in a room, rather than creating, as envisioned for AWE, the physical room itself, rendered intelligent and embedded with a range of IT technologies. Our AWE research effort focuses less on developing and interfacing individual IT elements that might be embedded in AWE, and more on cultivating the dynamic, reinforcing and reconfigurable relationships between the digital and physical (i.e. environmental) realms responsive to workers and working life in a digital society.

Precedents that most significantly impact our development of AWE, a robot-room, are those few where Architectural and CISE researchers collaborate to realize intelligent physical environments. In broad theoretical terms, the AWE team is inspired by two such convergences drawn from William Mitchell's trilogy of books on IT and the built environment [15][16][17]. The first is Mitchell's vision of the building as a computer: "The building of the near future will function more and more like large computers" [16]. The second is Mitchell's vision of the building as a robot: "Our buildings will become…robots for living in" [16]. It is worth noting that Mitchell moves easily between MIT's School of Architecture and its Media Lab, and that his vision of the building-as-robot is not altogether radical when we recognize that the first known treatise of architecture, by Vitruvius, laid claims to machine design as the proper domain of architecture [13][20]. Indeed, the "smart house" projects by Mitchell's group [12] and others, and, more significantly, the programmable, robotic wall by dECOi [8] and robotic pavilions by Kas Oosterhuis [19], hint at the promise of converging architectural design, interface design and robotic design. AWE draws from these precedents the open source, chassis/plug-in strategy of MIT's *House_n* [12], the seamless integration of IT and architecture suggested by the MIT/FPC *Media House* [14], and the real-time configurability of the programmable *WEB* pavilion of Oosterhuis [19]. But as "houses," "walls," and "pavilions," these significant precedents for our research, by definition, are not explicitly designed for specified human activities and so, suffer from being too diffuse; whereas AWE, operating at the smaller scale of the room, employing novel morphing surfaces, and devoted to facilitating working life, makes more of its association of new technologies, the physical environment and very particular social conditions.

AWE Scenarios

The following scenario begins to illustrate the operation and promise of AWE.

Situation: Laura, a single-mother/biologist, presents her research proposal before a committee in two weeks. Laura's proposal draws significantly from documents in digital format, notes from a recent conference, a video she made, and several books. She is working on her proposal mostly at home but also at her faculty office. Meanwhile Laura's nephew Roberto, a college student, is visiting from Latin America.

Before AWE: Laura's documents are spread over the desk, computer, floor, and filing cabinet of her home office. Books are opened, face-down, to critical pages. One of these books and two of the digital papers are most important to her proposal. She's periodically disrupted by her four-year old child, Eric, who pulls materials off Laura's desk when he wants her attention. Laura senses that her nephew Roberto has a real interest in science, but she doesn't know how to sustain this interest over his visit, and, anyhow, he's on vacation – easily distracted and easily bored.

Working with AWE for the first time: AWE is installed and ready to operate in Laura's living room [fig. 1]. It looks to her more like a dining room table than an office desk, a cubicle, or a work station. Laura quickly recognizes six prominent icons on AWE's work surface that read: COMPOSING, PRESENTING, COLLABORATING,

MEETING, VIEWING, PLAYING. As Laura urgently needs to work on her research proposal, she imagines COMPOSING best defines her needs and engages that icon. Quickly and steadily, four ribbons descend from the ceiling, each embedded with a computer screen arrayed at eye level when seated at the work surface [fig. 2].

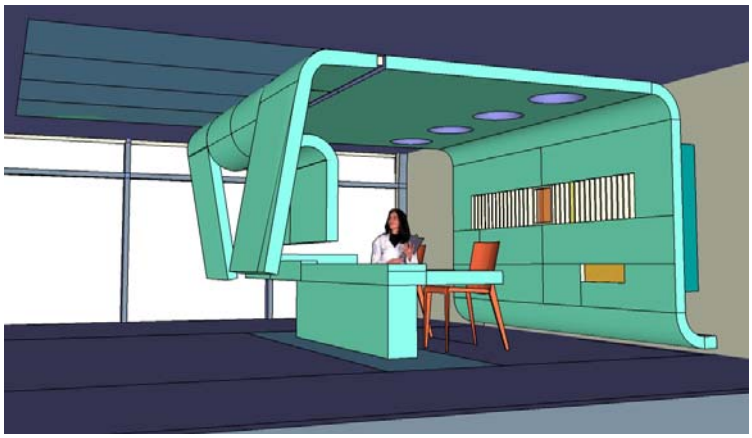

fig. 2: AWE concept - COMPOSING

The four screens light-up and a keyboard and mouse pop up from the work surface. In the short time that AWE sets itself up for COMPOSING, Laura discovers a toggle option marked SMART / PROGRAM and decides on toggling SMART mode. Nothing happens; that is, until Laura has organized her printed materials and coffee cup on AWE's work surface and sits before its array of four lit screens. Laura takes notice of a slowly moving curtain encircling one end of AWE's work surface to provide privacy and sound dampening for COMPOSING. Laura's scientific mind correctly infers that AWE, in its simple intelligence, has recognized that she is presently seated, COMPOSING, and so is likely to require this kind of gentle enclosure to facilitate her work. She also senses that AWE has adjusted its overhead lighting to facilitate her focused work. But the desk is too low for Laura's height. Laura moves her hand towards the work surface where she sees the outline of a hand, marked RISE, at which point the surface rises to a height at which Laura is comfortable. The surface stops rising when Laura removes her hand. Laura now presses and holds the COMPOSING button to save this particular setting and then types "Laura – Research Presentation" to define this personal setting. At a later occasion, Laura can simply press COMPOSING to return AWE to this configuration.

Laura now assigns four digital documents to the four digital screens: two screens display the two most important articles, a third displays the video, and the fourth screen displays the titles of some non-digital documents Laura is using to compose the presentation – her handwritten conference notes, nine printed articles, and four books. Laura clicks on the title of a particular printed article she's soon to need, and the screen reports to her that this article (with attached RFID tag), is located in slot-24 of AWE's physical filing system. The lit door over file slot-24 helps Laura quickly locate and retrieve the article.

Laura now touches, one at a time, the two screens displaying the two most important articles for her proposal and these, in AWE's simple intelligence, follow Laura's

hand, extending and slightly twisting to a more accessible position for her. In a like manner, Laura sends the two screens displaying the video and the non-digital documents a short distance away and above her so that she is aware of, but not distracted by them.

Forty minutes into her work, Laura becomes aware of her son Eric, growing restless. But Eric, seeing his mother intently working through AWE's translucent privacy curtain, entertains himself for another five minutes. Then, the inevitable: Eric, intent on getting his mother's attention, lunges for the printed article Laura has just retrieved. At that moment, Laura toggles the icon on AWE's work surface labeled COVER/UNCOVER to COVER. A thin but sturdy surface originates from below, covering Laura's materials that had been distributed methodically by her across the work surface. The new surface provides space for Laura and Eric to color some pictures for ten minutes – their pact.

After ten minutes of coloring, Eric seems content to entertain himself for a little while longer, and Laura toggles UNCOVER to reveal the organization of her work surface again. Laura decides it's time to rehearse the first segment of her presentation. Simply engaging the PRESENTING icon establishes the new configuration (fig. 3). (Alternatively, Laura could select INTENT INFERENCING in AWE's set-up menu, so that AWE begins configuring the PRESENTING mode when it recognizes Laura standing in a location where one would give a presentation.) In PRESENTING mode, three of AWE's display screens retract into the ceiling and the fourth screen, displaying Laura's developing *Powerpoint* presentation, spins 180 degrees to face her. Three projectors also are turned on: one projects the *Powerpoint* presentation on the wall surface next to Laura while the other two projectors display, on two adjacent walls, the visual sensation of a small lecture hall where one might make a presentation. AWE's lighting and acoustics are likewise adjusted to simulate the atmosphere of the hall.

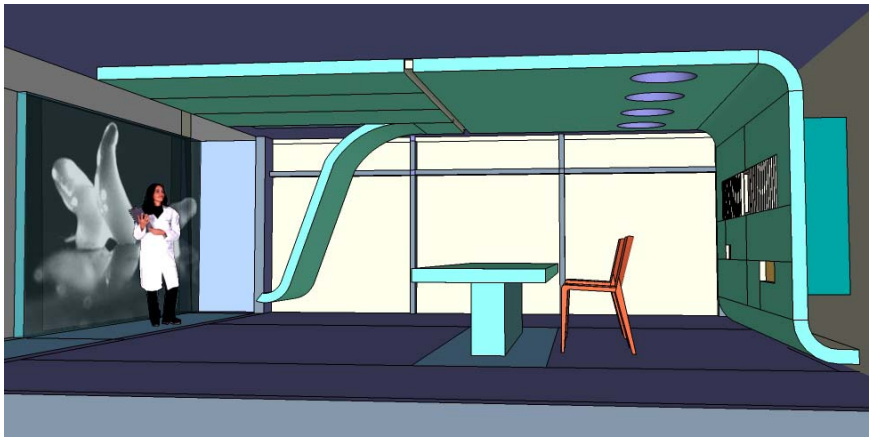

fig. 3. AWE concept – PRESENTING

After 30 minutes of rehearsing, Laura remembers its time she drop Eric at the day care and then, to return to her faculty office for a scheduled appointment. Before leaving the house, Laura withdraws, from a USB port in AWE, a portable storage device containing the digital information held in her home-based AWE system.

Stopped at a red traffic light on her way to the University, Laura has an epiphany about her developing proposal. Upon entering her faculty lab where AWE is also installed, Laura inserts the portable storage device into AWE to quickly match the AWE configuration she left at home. Without having to reach for a notepad and without losing the time of transcription, Laura is easily integrating her "epiphany" into the developing presentation. Laura also adjusts AWE's on-screen ATMOSPHERE settings to better approximate, for her next rehearsal, the sense of the conference room where she will finally present her proposal.

At home, Roberto employs AWE to view materials that Laura has given him access to. Among these is a recording of Laura's earlier conversation with Roberto about AWE and her developing work, presented by AWE as a video for Roberto to review and examine. Roberto, a college student, prefers lounging in an upholstered chair to sitting at a desk. Using AWE's simple intelligence, Roberto adjusts AWE's work surface from the default VIEWING configuration to a slightly tilted and lower configuration that better suits his lounging. As well, Roberto elects to bring the single screen displaying Laura's video more proximate to him, guiding the screen with his hand. Roberto saves this VIEWING figuration as, simply, "Roberto" for future retrieval.

When Laura returns from the University, Roberto excitedly announces to his aunt that using AWE, he's discovered a curious link between something she's considering in her research and research activities occurring in his native country, which he discovered on the internet.

When Roberto grows tired from all his explorations facilitated by AWE, Laura, with a simple activation of the COMPOSING option, recovers the physical organization of her materials as before, and continues developing her presentation.

In sum, AWE affords responsiveness to needs – particular and dynamic, cognitive and kinesthetic – of individual users in fluid social organizations and work patterns.

Current and Future Directions of the Project

AWE is a direct extension of the activities within Clemson University's *Animated Architecture Lab*, a research and teaching body founded by the author in which engineering, architecture and the social sciences converge. Four interrelated collaborative activities define our planned efforts: (1) a survey, analysis and theory of relevant working conditions (led by the sociologist investigator); (2) an ethnographic study of the work activities of information workers, as well as the usability evaluation of several alternative AWE concepts and full-scale prototypes (led by the human-factors investigator); (3) the design of alternative AWE concepts, and the demonstration of AWE as a total concept, first as a digital animation and second as a full-scale prototype (led by the architect-author); and (4) the development of the core continuous surface (figures 4 and 5) and its user interface with formative usability testing of prototype surfaces, as well as its integration into a full-scale prototype of the total concept (led by the robotics investigator). The results of these efforts will be reported in future papers. The AWE project will be realized, as a result of these efforts, as a working prototype at full scale at Clemson University.

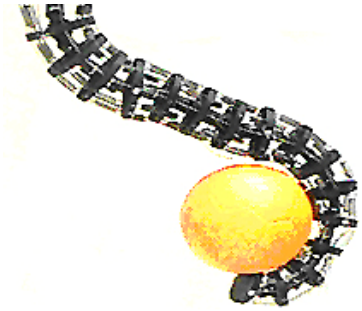

fig. 4: Clemson Continuum Robot
The biologically inspired robot shown here has already been accomplished by one member of the AWE research team.

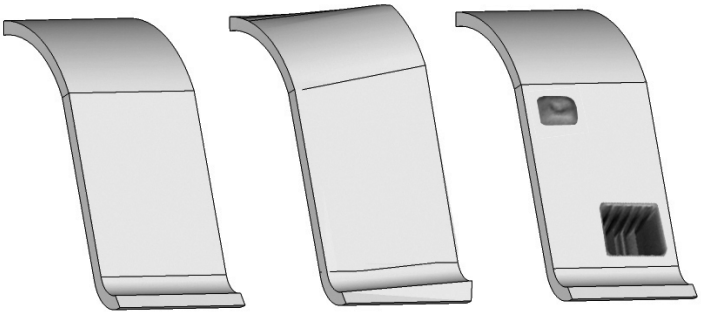

fig. 5: Three Potential Conditions for AWE's Ribbons
The AWE team is extending the technology of the Continuum Robot show in figure 4 to create AWE's morphing surfaces shown here as bending, twisting, and shape-shifting.

In sum, AWE, by recognizing the physical environment as an integral aspect of the dynamic interaction between people and the digital realm, constitutes an early, socially significant initiative by a team of "collaborative environment designers," defined by Mark Burry as "architects" working "along with their new collaborating experts…in computer science…and engineering" [7].

Conclusions

The AWE project suggests how architecture faculty might expand the reach of architecture while maintaining the core of what they do well: designing. This, however, does not come easily. Design research of the kind I described here is, according to Italian architect and Ivrea Institute faculty member, Stefano Mirti, "something rather new; [..] there isn't much written on it, there aren't many examples of it, and most likely the thing has to be completely shaped from scratch" [11].

Challenges for architecture faculty working on such collaborative design research projects include:

- The need to be well-versed in subjects outside of architecture in order to begin the "conversation" across participating colleagues from other disciplines.

- The need to "bring something to the table" to colleague-collaborators in the way of skills, perspective and vision – incentives to collaborators from outside architecture to participate in a joint project with an architect-investigator.

- The need for sufficient time outside of teaching and service to realize the ambitions of the research when architectural faculty members tend to be saddled with demanding teaching schedules (studio and seminar teaching in professional degree programs rather than post-professional degree programs). As a policy, the funding awarded by bodies like the National Science Foundation will not support "teaching release" time, assuming that Engineers and Scientists – the typical recipients – have teaching loads of only three to six contact hours per week (with doctoral students covering their lab courses).

- The need for a suitable infrastructure to accomplish the research which includes a laboratory, meeting spaces, and well-prepared post-professional M.S. and Ph.D. students more than M.Arch. professional-degree students engaged in the research project as part, or the core of, their educational requirements.

- The need to, in effect, restructure the way university administrations practice the oversight of research practices, as collaborative research projects (e.g. the AWE Project) tend to extend across more than one university College, making approvals, contracts and negotiations more complicated given the diverse pool of university officials associated with the project.

- The need to overcome stiff competition for scarce funding in difficult times for many funding bodies. (NSF, for one, has suffered a 10% reduction in federal funding this year.)

Despite these obstacles, collaborative design research projects like AWE have the capacity to redefine research not only within architecture but in all disciplines that comprise such collaborative research teams. More broadly, collaborative research teams, like the AWE team, collaborate in order to realize responsive and complex design prototypes that promise to improve everyday life in an increasingly connected and complex society.

Thanks to my AWE collaborators:
Lee Gugerty, Ian Walker and Jim Witte

REFERENCES

[1] "'Q' Mobile workstation concept for Steelcase," 2005, posting date. http://www.ideo.com/portfolio/re.asp?x=12378 [online].

[2] "IBM Blue Space Research," 2005, posting date. http://www.research.ibm.com/bluespace [online].

[3] Aarts, E. and Marzano. S. *The New Everyday: Views on Ambient Intelligence*, Rotterdam: 010 Publishers, 2003.

[4] Beyer, H. & Holtzblatt, K. *Contextual Design: Defining Customer-Centered Systems*. San Francisco, CA: Morgan Kaufman Publishers, 1999.

[5] Binder, T., De Michelis, G., Gervautz, M., Jacucci, G., Matkovic, K., Psik, T., & Wagner, I. "Supporting configurability in a mixed-media environment for design students." In *Personal Ubiquitous Computing*, Vol. 8, Issue 5, 2004, pp. 310-325.

[6] Bondarenko, O. & Janssen, R., "Documents at Hand: Learning from Paper to Improve Digital Technologies." In *Proceedings of the Computer-Human-Interaction (CHI) 2005 Conference*, Association for Computing Machinery, 2005.

[7] Burry, M. "Convergent Design," [abstract]. Presentation at the *Futureground International Conference of the Design Research Society*, Monash University (Melbourne, Australia), 2004.-

[8] deCOI. "Aegis Hypersurface." In Mark Galthorpe/dECOi, "Precise Indeterminacy," *Praxis: Journal of Writing and Building*, Issue 6, March 2004.

[9] Ganz, A. Principal Investigator, "NeTS: Animated Spaces for the Digital Society: The ASPEN Architecture," NSF Award Abstract - #0434985.

[10] Garlan, D., Siewiorek, D., Smailagic, A. & Steenkiste, P. "Project Aura: Toward Distraction-Free Pervasive Computing." In *IEEE Pervasive Computing*, April-June 2002, pp. 22-30.

[11] Interaction Design Institute IVREA, post date, 2004. http://www.interaction-ivrea.it/en/about/interactiondesign/index.asp [online].

[12] Larson, K. "House_n Current Projects," post date, 2004. http://architecture.mit.edu/~kll/Project%20List%20Sept-2004.pdf [online].

[13] McCarter, R., ed., *Building; Machine*s. New York: Pamphlet Architecture/Princeton Architectural Press, 1987.

[14] MIT Media Lab/FPC, *Media House Project: BCN 26.09-06.10*, Barcelona: FPC, 2002.

[15] Mitchell, W. J. *City of Bits*. Cambridge, MA: MIT, 2000.

[16] Mitchell, W. J., *e-topia*. Cambridge, MA: MIT, 2000.

[17] Mitchell, W. J., *ME++*. Cambridge, MA: MIT, 2003.

[18] Niranjan R. K. & Ganz, A. "Animated Space Architecture for Multimedia Experience – ASkME." In Proceedings, *Broadnets 2004*, San Jose, 2004, pp. 1-6.

[19] Oosterhuis, K. *Hyperbodies: Towards an E-motive architecture*. Basel, Switzerland: Birkäuser, 2003.

[20] Vitruvius, *De Architectura [On Architecture]*, trans. F. Granger. Cambridge: Harvard, 1985.

[21] Wang, D. "Categories of ACSA Conference Papers: A Critical Evaluation of Architectural Research in Light of Social Science Methodological Frameworks." In the *Journal of Architectural Education*, Col. 57, Issue 4, May 2003, pp. 50-56.